

Application No: 10/612,439 Docket No.: Q170-US1

Page 6

REMARKS

Claims 1, 4-5, 65, 68, and 81 are currently amended. Claims 3, 6-9, and 66-67, 69-80 were previously presented. Claim 2 was previously withdrawn. Claims 10-64 were previously cancelled. Accordingly, claims 1, 3-9, and 65-81 are pending examination.

Rejection of Claim 1 Under 35 USC §102(a)

Claim 1 stands rejected under 35 USC §102(a) as being anticipated by either Hydro-Quebec WO 02/27823 or Hydro-Quebec WO 02/27824. The Office Actions cite the teachings in US2004/0033360 (Armand) as representing the teachings of WO 02/27823 and Hydro-Quebec WO 02/27824.

In response to the Applicant's previous argument, the Office Action points to Armand's Examples 1', 2, 3, and 13. However, these examples do not anticipate the Applicant's claim. In each of these examples, the source of carbon in the coating is non-gaseous cellulose acetate and not the gaseous phase. The purpose of the gas phase is to reduce a transition metal (iron in the cited examples). This idea can be discerned from Example 2 which provides the following in paragraph [0131]:

Thus it is evident that the carbon that comes from decomposition of the cellulose acetate is not consumed and does not interfere in the reaction that reduces iron (III) to iron (II). **Thus this reduction is carried out by means of the gaseous phase.**

A more generalized version of this teaching can also be found in paragraph [0066]. As a result, the gaseous phase provides a reducing atmosphere.

In contrast, the non-gaseous cellulose acetate present in these examples serves as the source of carbon for the coating. Although this idea can be discerned from each of the examples, it is particularly clear from example 1 which provides the following in paragraph [0121]:

This sample contains 1% by weight of carbon, which corresponds to a carbonization yield of the cellulose acetate of 20%.

Example 3 goes further and shows a correlation between the amount of cellulose acetate and the resulting amounts of carbon coating. For instance, paragraph [0141] states the following:

Application No: 10/612,439 Docket No.: Q170-US1

Page 7

As can be seen, the quantities of carbon conductor are proportional to the quantity of precursor added (cellulose acetate). *Parentheses in original.* Accordingly, the cellulose acetate in these examples is the source of the carbon in the coating.

Further, each of these examples teaches that the cellulose acetate is in a non-gas phase as shown in the following table.

Example	Paragraph	Quotation with emphasis added
1'	[0121]	The triphylite obtained in example I is impregnated with a <u>solution of cellulose acetate</u> ... in acetone.
2	[0127]	In a first step, the stoichiometric quantities of the two compounds, as well as the carbon source, (<u>cellulose acetate</u> , 39.7% by weight of acetyl, average molecular weight M_w of 50,000) ... <u>are crushed together</u> in isopropanol
3	[0136]	In a first step, the stoichiometric quantities of the two compounds, as well as <u>the cellulose acetate</u> , <u>are ground together</u> in isopropanol.
13	[0185]	The carbon additive mixture contains polyethylene-block-poly(ethylene glycol) as described in the previous examples, <u>dissolved in isopropanol and cellulose acetate.</u>

During the formation of the carbon coating, the cellulose acetate is pyrolyzed (paragraph [0048] and [0049]). As a result, the coating formed in these examples is not a "coating consisting of carbon from (a) source gas" as is claimed. Since Armand does not teach every element of claim 1, Armand does not anticipate claim 1.

Application No: 10/612,439 Docket No.: Q170-US1

Page 8

Attachment

The Applicant has attached a document describing the process of pyrolysis <http://en.wikipedia.org/wiki/Pyrolysis> as downloaded from the Internet on May 25, 2009.

Claims 3-9, 65-81

Each of claims 3-9, and 65-81 depend from independent claim 1. Since independent claim 1 is believed to be in condition for allowance, Claims 3-9, and 65-81 are also believed to be in condition for allowance.

Application No: 10/612,439 Docket No.: Q170-US1

Page 9

CONCLUSION

The Examiner is encouraged to telephone the undersigned with any questions.

Respectfully submitted,



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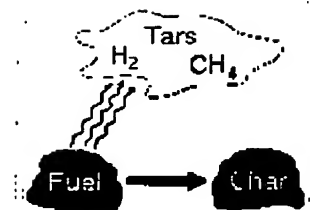
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Pyrolysis

From Wikipedia, the free encyclopedia

Pyrolysis is the chemical decomposition of a condensed substance by heating. The word is coined from the Greek-derived elements *pyro* "fire" and *lysis* "decomposition".

Pyrolysis is a special case of thermolysis, and is most commonly used for organic materials. It occurs spontaneously at high temperatures (ie above 300 °C for wood, it varies for other material), for example in wildfires or when vegetation comes into contact with lava in volcanic eruptions. It does not involve reactions with oxygen or any other reagents but can take place in their presence. Extreme pyrolysis, which leaves only carbon as the residue, is called carbonization and is also related to the chemical process of charring.



Simple sketch of pyrolysis chemistry.

Pyrolysis is heavily used in the chemical industry, for example, to produce charcoal, activated carbon, methanol and other chemicals from wood, to convert ethylene dichloride into vinyl chloride to make PVC, to produce coke from coal, to convert biomass into syngas, to turn waste into safely disposable substances, and for the cracking of medium-weight hydrocarbons from oil to produce lighter ones like gasoline.

It is an important chemical process in several cooking procedures such as baking, frying, grilling, and caramelizing. Pyrolysis is also a tool of chemical analysis, for example by pyrolysis gas chromatography mass spectrometry and in carbon-14 dating. Indeed, many important chemical substances, such as phosphorus and sulfuric acid, were first obtained by this process. It has been assumed to take place during catagenesis, the conversion of buried organic matter to fossil fuels. Pyrolysis is also the basis of pyrography.

Although water is normally excluded along with other reagents, the term has also been applied to the decomposition of organic material in the presence of superheated water or steam (hydrous pyrolysis), for example in the steam cracking of oil.

Contents

- 1 Occurrence and uses
 - 1.1 Fire
 - 1.2 Cooking
 - 1.3 Charcoal
 - 1.4 Biochar
 - 1.5 Coke
 - 1.6 Carbon fiber
 - 1.7 Biofuel
 - 1.8 Plastic waste disposal
- 2 Processes
- 3 Vacuum pyrolysis

■ 3.1 Processes for biomass pyrolysis

- 4 Industrial sources
- 5 Industrial products
- 6 Fire protection
- 7 See also
- 8 References
- 9 External links

Occurrence and uses

Fire

Pyrolysis is usually the first chemical reaction that occurs in the burning of many solid organic fuels, like wood, cloth, and paper, and also of some kinds of plastic. In a wood fire, the visible flames are not due to combustion of the wood itself, but rather of the gases released by its pyrolysis; whereas the flame-less burning of embers is the combustion of the solid residue (charcoal) left behind by it. Thus, the pyrolysis of common materials like wood, plastic, and clothing is extremely important for fire safety and fire-fighting.

Cooking

Pyrolysis occurs whenever food is exposed to high enough temperatures in a dry environment, such as roasting, baking, toasting, grilling, etc.. It is the chemical process responsible for the formation of the golden-brown crust in foods prepared by those methods.

In normal cooking, the main food components that suffer pyrolysis are carbohydrates (including sugars, starch, and fiber) and proteins. Pyrolysis of fats requires a much higher temperature, and since it produces toxic and flammable products (such as acrolein), it is generally avoided in normal cooking. It may occur, however, when barbecuing fatty meats over hot coals.

Even though cooking is normally carried out in air, the temperatures and environmental conditions are such that there is little or no combustion of the original substances or their decomposition products. In particular, the pyrolysis of proteins and carbohydrates begins at temperatures much lower than the ignition temperature of the solid residue, and the volatile subproducts are too diluted in air to ignite. (In flambé dishes, the flame is due mostly to combustion of the alcohol, while the crust is formed by pyrolysis as in baking.)

Pyrolysis of carbohydrates and proteins require temperatures substantially higher than 100 C, so pyrolysis does not occur as long as free water is present, e.g. in boiling food — not even in a pressure cooker. When heated in the presence of water, carbohydrates and proteins suffer gradual hydrolysis rather than pyrolysis. Indeed, for most foods, pyrolysis is usually confined to the outer layers of food, and only begins after those layers have dried out.

Food pyrolysis temperatures are however lower than the boiling point of lipids, so pyrolysis occurs when frying in vegetable oil or suet, or basting meat in its own fat.

Pyrolysis also plays an essential role in the production of barley tea, coffee, and roasted nuts such as peanuts and almonds. As these consist mostly of dry materials, the process of pyrolysis is not limited to the outermost layers but extends throughout the materials. In all these cases, pyrolysis creates or releases

many of the substances that contribute to the flavor, color, and biological properties of the final product. It may also destroy some substances that are toxic, unpleasant in taste, or those that may contribute to spoilage.

Controlled pyrolysis of sugars starting at 170 C produces caramel, a beige to brown water-soluble product which is widely used in confectionery and (in the form of caramel coloring) as a coloring agent for soft drinks and other industrialized food products.

Solid residue from the pyrolysis of spilled and splattered food creates the brown-black encrustation often seen on cooking vessels, stove tops, and the interior surfaces of ovens.

Charcoal

Pyrolysis has been used since ancient times for turning wood into charcoal in an industrial scale. Besides wood, the process can also use sawdust and other wood waste products.

Charcoal is obtained by heating wood until its complete pyrolysis (carbonization), leaving only carbon and inorganic ash. In many parts of the world, charcoal is still produced semi-industrially, by burning a pile of wood that has been mostly covered with mud or bricks. The heat generated by burning part of the wood and the volatile byproducts pyrolyzes the rest of the pile. The limited supply of oxygen prevents the charcoal from burning too. A more modern alternative is to heat the wood in an airtight metal vessel, which is much less polluting and allows the volatile products to be condensed.

The original vascular structure of the wood and the pores created by escaping gases combine to produce a light and porous material. By starting with dense wood-like material, such as nutshells or peach stones, one obtains a particularly porous form of charcoal, called activated carbon, which is used as an adsorbent for a wide range of chemical substances.

Biochar

Residues of incomplete organic pyrolysis, e.g. from cooking fires, are thought to be the key component of the terra preta soils associated with ancient indigenous communities of the Amazon basin.^[1] Terra preta is much sought by local farmers for its superior fertility compared to the natural red soil of the region. Efforts are underway to recreate these soils through biochar, the solid residue of pyrolysis of various materials, mostly organic waste.

Biochar improves the soil texture and ecology, increasing its ability to retain fertilizers and release them slowly. It naturally contains many of the oligoelements needed by plants, such as selenium. It is also safer than other "natural" fertilizers such as manure or sewage since it has been disinfected at high temperature, and since it releases its nutrients at a slow rate, it greatly reduces the risk of water table contamination.^[2]

Biochar is also being considered for carbon sequestration, with the aim of mitigation of global warming.^[3] ^[4]

Coke

Pyrolysis is used on a massive scale to turn coal into coke for metallurgy, especially steelmaking. Coke can also be produced from the solid residue left from petroleum refining.

Those starting materials typically contain hydrogen, nitrogen or oxygen atoms combined with carbon into molecules of medium to high molecular weight. The coke-making or "coking" process consists in heating the material in closed vessels to very high temperatures (up to 2000 C), so that those molecules are broken down into lighter volatile substances, which leave the vessel, and a porous but hard residue that is mostly carbon and inorganic ash. The amount of volatiles varies with the source material, but is typically 25-30 % of it by weight.

Carbon fiber

Carbon fibers are filaments of carbon that can be used to make very strong yarns and textiles. Carbon fiber items are often produced by spinning and weaving the desired item from fibers of a suitable polymer, and then pyrolyzing the material at a high temperature (from 1500 C to 3000 C).

The first carbon fibres were made from rayon, but polyacrylonitrile has become the most common starting material.

For their first workable electric lamps, Joseph Wilson Swan and Thomas Edison used carbon filaments made by pyrolysis of cotton yarns and bamboo splinters, respectively.

Biofuel

Pyrolysis is the basis of several methods that are being developed for producing fuel from biomass, which may include either crops grown for the purpose or biological waste products from other industries.^[5]

Although synthetic diesel fuel cannot yet be produced directly by pyrolysis of organic materials, there is a way to produce similar liquid ("bio-oil") that can be used as a fuel, after the removal of valuable bio-chemicals that can be used as food additives or pharmaceuticals.^[6] Higher efficiency is achieved by the so-called flash pyrolysis where finely divided feedstock is quickly heated to between 350 and 500 C for less than 2 seconds.

Fuel bio-oil resembling light crude oil can also be produced by hydrous pyrolysis from many kinds of feedstock, including waste from pig and turkey farming, by a process called thermal depolymerization (which may however include other reactions besides pyrolysis).

Plastic waste disposal

Anhydrous pyrolysis can also be used to produce liquid fuel similar to diesel from plastic waste.^[6] [7]

Processes

In many industrial applications, the process is done under pressure and at operating temperatures above 430 °C (806 °F)

- agricultural waste: 450 to 550 °C

Vacuum pyrolysis

In **vacuum pyrolysis**, organic material is heated in a vacuum in order to decrease boiling point and avoid adverse chemical reactions. It is used in organic chemistry as a synthetic tool. In **flash vacuum thermolysis** or **FVT**, the residence time of the substrate at the working temperature is limited as much as possible, again in order to minimize secondary reactions.

Processes for biomass pyrolysis

Since pyrolysis is endothermic,^[8] various methods have been proposed to provide heat to the reacting biomass particles:

- Partial combustion of the biomass products through air injection. This results in poor-quality products.
- Direct heat transfer with a hot gas, ideally product gas that is reheated and recycled. The problem is to provide enough heat with reasonable gas flow-rates.
- Indirect heat transfer with exchange surfaces (wall, tubes). It is difficult to achieve good heat transfer on both sides of the heat exchange surface.
- Direct heat transfer with circulating solids: Solids transfer heat between a burner and a pyrolysis reactor. This is an effective but complex technology.

For flash pyrolysis the biomass must be ground into fine particles and that the insulating char layer that forms at the surface of the reacting particles must be continuously removed. The following technologies have been proposed for biomass pyrolysis:^[9]

- Fixed beds were used for the traditional production of charcoal. Poor, slow heat transfer resulted in very low liquid yields.
- Augers: This technology is adapted from a Lurgi process for coal gasification. Hot sand and biomass particles are fed at one end of a screw. The screw mixes the sand and biomass and conveys them along. It provides a good control of the biomass residence time. It does not dilute the pyrolysis products with a carrier or fluidizing gas. However, sand must be reheated in a separate vessel, and mechanical reliability is a concern. There is no large-scale commercial implementation.
- Ablative processes: Biomass particles are moved at high speed against a hot metal surface. Ablation of any char forming at the particles surface maintains a high rate of heat transfer. This can be achieved by using a metal surface spinning at high speed within a bed of biomass particles, which may present mechanical reliability problems but prevents any dilution of the products. As an alternative, the particles may be suspended in a carrier gas and introduced at high speed through a cyclone whose wall is heated; the products are diluted with the carrier gas.^[10] A problem shared with all ablative processes is that scale-up is made difficult since the ratio of the wall surface to the reactor volume decreases as the reactor size is increased. There is no large-scale commercial implementation.
- Rotating cone: Pre-heated hot sand and biomass particles are introduced into a rotating cone. Due to the rotation of the cone, the mixture of sand and biomass is transported across the cone surface by centrifugal force. Like other shallow transported-bed reactors relatively fine particles are required to obtain a good liquid yield. There is no large scale commercial implementation.^[11]
- Fluidized beds: Biomass particles are introduced into a bed of hot sand fluidized by a gas, which is usually a recirculated product gas. High heat transfer rates from fluidized sand result in rapid heating of biomass particles. There is some ablation by attrition with the sand particles, but it is not as effective as in the ablative processes. Heat is usually provided by

heat exchanger tubes through which hot combustion gas flows. There is some dilution of the products, which makes it more difficult to condense and then remove the bio-oil mist from the gas exiting the condensers. This process has been scaled up by companies such as Dynamotive and Agri-Therm. The main challenges are in improving the quality and consistency of the bio-oil.

- Circulating fluidized beds: Biomass particles are introduced into a circulating fluidized bed of hot sand. Gas, sand and biomass particles move together, with the transport gas usually being a recirculated product gas, although it may also be a combustion gas. High heat transfer rates from sand ensure rapid heating of biomass particles and ablation is stronger than with regular fluidized beds. A fast separator separates the product gases and vapors from the sand and char particles. The sand particles are reheated in fluidized burner vessel and recycled to the reactor. Although this process can be easily scaled up, it is rather complex and the products are much diluted, which greatly complicates the recovery of the liquid products.

Industrial sources

- domestic refuse: Pyrolysis is used as a form of thermal treatment to reduce waste volumes
- sawdust and waste wood

There is also the possibility of integrating with other processes such as mechanical biological treatment and anaerobic digestion.^[12]

Industrial products

- syngas (flammable mixture of carbon monoxide and hydrogen): can be produced in sufficient quantities to both provide the energy needed for pyrolysis and some excess production^{[3][13]}
- solid char that can either be burned for energy or recycled as a fertilizer (biochar).

Fire protection

Destructive fires in buildings will often burn with limited oxygen supply, resulting in pyrolysis reactions. Thus, pyrolysis reaction mechanisms and the pyrolysis properties of materials are important in fire protection engineering for passive fire protection. Pyrolytic carbon is also important to fire investigators as a tool for discovering origin and cause of fires.

See also

- Cracking (chemistry)
- Destructive distillation
- Dry distillation
- Gasification
- Karrick process
- Pyrolytic coating
- Wood gas

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Pyrolysis - Wikipedia, the free encyclopedia

Page 7 of 7

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External links

Retrieved from "<http://en.wikipedia.org/wiki/Pyrolysis>"

Categories: Biodegradable waste management | Bioenergy | Organic reactions | Waste treatment technology | Fire protection | Chemical processes

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